

Type B Accident
Investigation Board Report
on the July 7, 1997
Industrial Accident
at the
Knolls Atomic Power Laboratory-
Windsor Site

Schenectady Naval Reactors Office
U. S. Department of Energy

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EXECUTIVE SUMMARY

INTRODUCTION

An accident was investigated in which a laborer stepped on and fell backward through an unprotected rooftop skylight at the Knolls Atomic Power Laboratory (KAPL)-Windsor Site. In conducting the investigation, the Accident Investigation Board used various analysis techniques, including barrier analysis, change analysis, and root cause analysis. The Board inspected, photographed and videotaped the accident scene; collected and analyzed physical evidence; conducted interviews of personnel involved (including the subject); and compiled and reviewed all relevant DOE and contractor documentation. The Board also examined the policies, standards, and requirements that were relevant to the accident as well as management and safety systems that could have contributed to or prevented the accident.

ACCIDENT DESCRIPTION

The accident occurred at approximately 10:47 a.m., on Monday, July 7, 1997, at the Windsor Site when a laborer employed by National Surface Cleaning Corporation (NSC) stepped on and fell through an unprotected rooftop skylight that had not been recognized as a hazard. The laborer fell approximately 37 feet but did not contact the floor because the lifeline of his fall arrest system became entangled with the skylight hatch coaming and a small diameter nylon rope being used as an OSHA control line on the roof. The laborer was approximately one foot above the floor when his lifeline became taut. The laborer, who suffered only minor injuries during the fall, was transported by helicopter to a local hospital where he was treated and subsequently released on July 10, 1997.

DIRECT AND ROOT CAUSES

The direct cause of the accident was the laborer stepping on and falling through an unprotected rooftop skylight. The root causes of the accident were:

- NSC management failed to ensure that fall protection requirements were understood and properly implemented in accordance with both contractual and applicable regulatory requirements.
- KAPL and EB failed to identify and resolve the reasons for recurring fall protection deficiencies noted prior to the accident. WFO failed to ensure that chronic fall protection problems were brought to the attention of and resolved by KAPL and EB senior management.

PROLOGUE

INTERPRETATION OF SIGNIFICANCE

The accident at Knolls Atomic Power Laboratory (KAPL), Windsor Site, on July 7, 1997, resulted from a failure of on-site management to recognize and correct a chronic safety performance problem with fall protection. Electric Boat (EB), the general contractor, and EB's subtier asbestos abatement subcontractor, National Surface Cleaning Corporation (NSC), had a record of continuing fall protection deficiencies which EB and NSC corrected on a "case by case" basis rather than identifying and correcting the root causes of the deficiencies.

Although the appropriate contractual and procedural safety requirements were in place, NSC failed to implement them. NSC's safety monitor lacked sufficient knowledge of the fall protection requirements and failed to recognize rooftop skylights as a fall hazard requiring protection. This chronic problem was not recognized despite the several layers of oversight (EB, Olshan, and KAPL). Fall protection deficiencies were noted by KAPL and EB, but management did not address the larger concern that the subcontractor lacked a fundamental understanding of the requirements. This situation was exacerbated by the absence of a strong EB safety organization. EB relied too heavily on KAPL to identify most of the deficiencies. The DOE Windsor Field Office failed to ensure that chronic fall protection problems were brought to the attention of and resolved by KAPL and EB senior management.

This event, which could have resulted in a fatality but for some degree of fall protection, highlights the importance of holding subcontractors accountable to the applicable safety requirements and ensuring that they have a full understanding of what actions need to be taken to provide a safe work environment. Contractors must fully accept this responsibility for both their workforce as well as their subcontractors.

1.0 INTRODUCTION

1.1 BACKGROUND

On Monday, July 7, 1997, at approximately 10:47 a. m., an asbestos abatement subcontractor laborer working at the Knolls Atomic Power Laboratory-Windsor Site stepped on and fell backward through an unprotected rooftop skylight in the northwest quadrant of Building 5 (see Figure #1). The laborer, who was wearing a full body safety harness, fell approximately 37 feet. The fall was arrested prior to the subject's torso contacting the building floor when his lifeline became entangled with a small diameter nylon rope being used as a control line on the roof to identify areas requiring fall protection. During the fall, the laborer contacted a metal conduit, firemain piping and, according to one witness, a metal handrail before coming to rest approximately one foot above the concrete building floor. The laborer was transported by helicopter to a local hospital, where his injuries were determined not to be life threatening. On July 10, 1997 he was released.

On July 8, 1997, P. E. Salm, Manager, Schenectady Naval Reactors Office, appointed a Type B Accident Investigation Board to investigate the accident in accordance with DOE Order 225.1, *Accident Investigations* (see Appendix A).

1.2 FACILITY DESCRIPTION

The Knolls Atomic Power Laboratory-Windsor Site located in Windsor, Connecticut, is owned by the U. S. Department of Energy (DOE). Its mission had been to conduct testing of a submarine prototype nuclear propulsion plant and to train U. S. Navy nuclear propulsion plant operators. The Windsor Site is currently operated by KAPL, Inc., a Lockheed Martin Company, under a contract with the U. S. Department of Energy.

In March 1993, as a result of the end of the Cold War and the downsizing of the Navy, the prototype was permanently shut down. Site inactivation is in progress. On December 30, 1996, the DOE Office of Naval Reactors announced plans to proceed with prompt dismantlement of the prototype and release of the Windsor Site for unrestricted use.

Site inactivation and prototype dismantlement is being performed by Electric Boat (EB) under a subcontract with KAPL Inc., the DOE prime contractor.

EB has subcontracted demolition work to Olshan Demolishing Management, Inc. (Olshan), who in turn has subcontracted with National Surface Cleaning Corporation (NSC) for the predemolition removal of asbestos-containing materials. Oversight of EB work is provided by a 25-person KAPL field office. The local government office, known as the Windsor Field Office (WFO), is staffed with two Naval officers, one of whom is head of the office, and a DOE engineer who are part of the DOE Office of Naval Reactors.

The requirements for establishing and maintaining an effective worker protection program at the Windsor Site, as identified in DOE Order 440.1, were invoked via Naval Reactors Implementation Bulletin 440.1.-93, dated February 14, 1997. To fulfill its responsibilities under this Order, KAPL provides oversight of all work performed on site. Under its subcontract with KAPL, EB is responsible for providing oversight of work performed by both EB and EB subcontractor personnel.

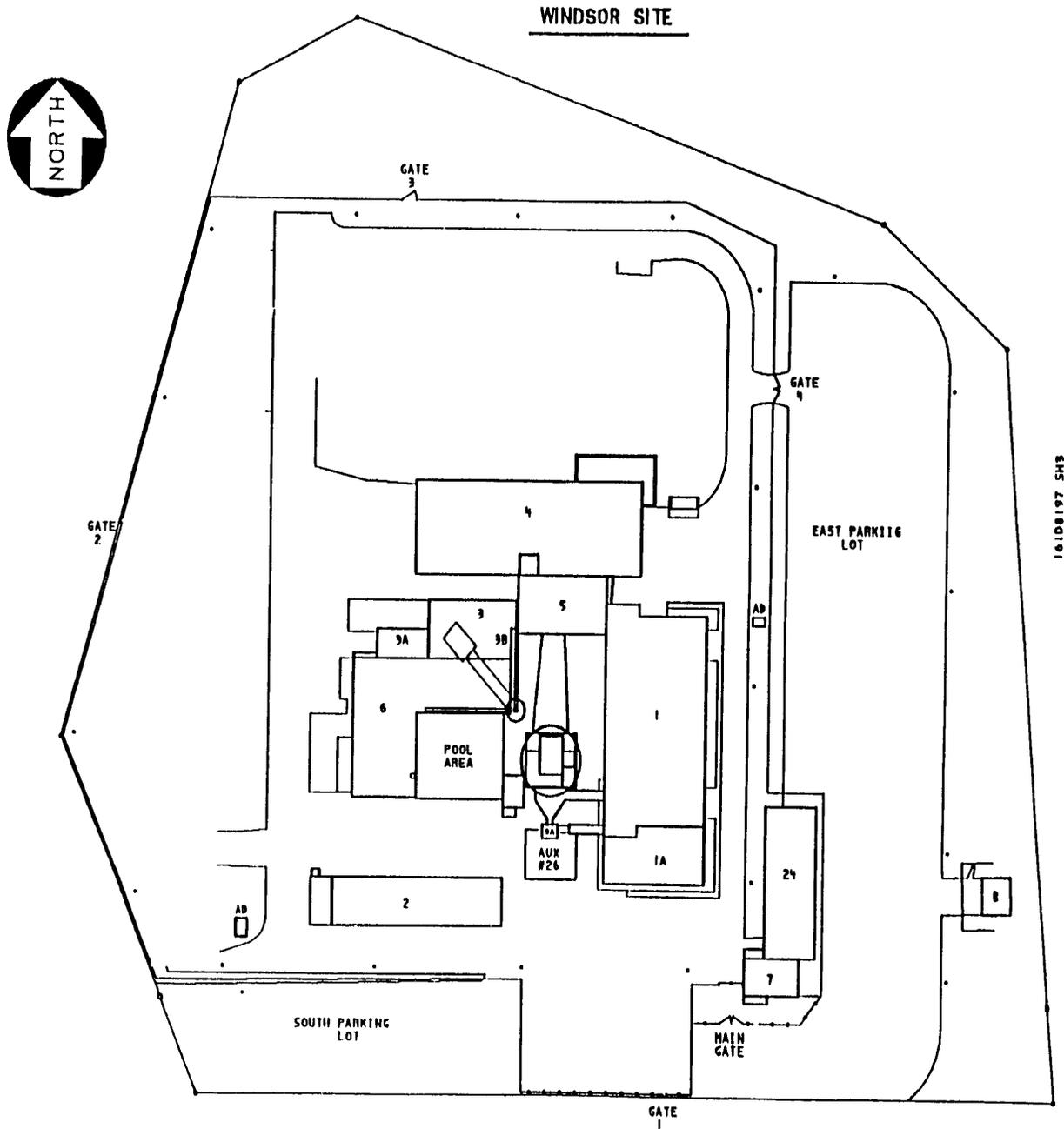


Figure 1 - Site map

1.3 SCOPE, CONDUCT, AND METHODOLOGY

The Board commenced its investigation on July 8, 1997, completed the investigation on July 25, 1997, and submitted its findings to the Manager, SNR on August 8, 1997.

The scope of the Board's investigation was to review and analyze the circumstances to determine the accident's causes. During the investigation, the Board inspected, videotaped, and photographed the accident scene; collected and analyzed physical evidence; conducted interviews of personnel involved (including the subject); compiled and reviewed all relevant DOE and contractor documentation, and performed causation analyses. The Board also examined the policies, standards, and requirements that were applicable to the accident as well as management and safety systems that could have contributed to or prevented the accident.

The purposes of the investigation were to determine the nature, extent, and causes of the event and any programmatic impact, and to assist in determining the actions that, when implemented, should prevent recurrence of the accident.

The Board conducted its investigation focusing on management systems at all levels using the following methodology:

- Facts relevant to the accident were gathered.
- Relevant management systems and factors that could have contributed to the accident were evaluated in accordance with DOE Order 225.1, *Accident Investigations*, dated July 26, 1996 and its Implementation Guide.
- Event and causal factors charting, along with barrier analysis and change analysis, was used to provide supportive correlation and identification of the causes of the accident.

2.0 FACTS AND ANALYSIS

2.1 ACCIDENT DESCRIPTION AND CHRONOLOGY

2.1.1 Background and Accident Description

The accident occurred at approximately 10:47 a.m. on Monday, July 7, 1997 at the Knolls Atomic Power Laboratory-Windsor Site, Building 5, when an asbestos abatement subcontractor laborer fell approximately 37 feet before his fall arrest system stopped him approximately one foot above the concrete floor. The laborer was employed by National Surface Cleaning Corporation (NSC), a subcontractor of Olshan Demolishing Management Inc.(Olshan). Olshan is a demolition subcontractor for Electric Boat (EB) who

is the subcontractor under KAPL for site inactivation and prototype dismantlement.

On November 18, 1996, Olshan subcontracted predemolition asbestos abatement work to NSC. By July, 1997, NSC had started removing the roof flashing (which contained non-friable asbestos) from Buildings 1, 1A, and 5. Building 5 is 38 feet tall and has a large open high bay. The roof of Building 5 has two Plexiglas domed skylights. Sketches depicting the Building 5 roof and an elevation view of the building are shown in Figures 2 and 3, respectively.

On July 7, 1997, at 7:00 a.m., the NSC Superintendent held the morning pre-job briefing. The work crew was divided into two separate groups. The first group of two laborers was tasked with covering up roof openings on Building 1. The second group of two laborers (including the subject of the fall) was assigned the task of removing flashing from the edge of the Building 5 roof. The work was to be supervised by a foreman, general foreman, and the NSC Superintendent. The Superintendent was NSC's designated competent person (safety monitor). The Superintendent advised the Board it was his practice to always be present when elevated work requiring fall protection was performed. The Board notes that OSHA 29 CFR 1926 Subpart M does not mandate the full-time presence of a safety monitor when a fall arrest system is utilized.

Immediately following the pre-job briefing, the NSC Superintendent held the daily safety briefing. The briefing covered fall protection, including maintaining the OSHA-required maximum six-foot fall limit and stressed the importance of covering roof openings. The briefing did not specifically address skylights as a roof opening or a fall hazard. Fall protection had been the topic of safety briefings for the past nine days because the crew was predominately working on roofs and falling was the most significant hazard.

Following the briefing at approximately 8:00 a.m., the work crews donned their personal protective equipment that included a full-body safety harness for fall protection and went up to the roofs. On Building 5, the foreman tied off each laborer after the correct length of rope to maintain a six-foot fall limit was determined based on the initial work area. The anchor points for



Subject's lifeline anchor point

the two laborers were two vents which had been determined by EB the previous week to be structurally adequate for this purpose in accordance with OSHA 29 CFR 1926.502(d)(15). The subject began working on the southeast corner of the Building 5 roof and worked his way north. The other laborer began on the southwest corner and worked north (with the intention of meeting in the center of the north edge).

At about 10:20 a.m., the NSC Superintendent had to attend to other duties for a short time requiring him to leave the roof area. He instructed the work crew on Building 5 to stop working and take a break until he returned. About five to ten minutes later, the EB Work Administrator (EB-WA) toured the Building 5 roof. The EB-WA is responsible for monitoring subcontractor work. His duties include ensuring that the work is performed safely and in accordance with contractually invoked requirements, such as OSHA standards. He observed the two assigned laborers working. The subject was working in the northeast corner of the roof. The other laborer was working in the vicinity of the northwest corner of the roof. No one else was on the roof. The EB-WA went onto the Building 1 roof and discussed some fall protection deficiencies with the NSC general foreman to pass along to the Superintendent when he returned. The EB-WA left the Building 5 roof at about 10:40 a.m.

At about 10:47 a.m., the NSC general foreman, who had returned to the Building 5 roof, observed the subject take a step backward to rest his foot on the skylight, lose his balance, and fall backward through the skylight. Another NSC laborer on the Building 5 roof also observed the fall. His observations to the Board were consistent with those of the NSC general foreman. In his interview with the Board, the subject stated that he had lost his balance immediately prior to the fall when he tripped on removed flashing material on the roof. The Board further pursued this inconsistency with the NSC Superintendent who had visited with and spoken to the subject while he was in the hospital. The NSC Superintendent advised the Board the subject stated he had stepped on the skylight, lost his balance when the skylight broke, and then fell through. The Board concludes that this is the most likely explanation of the events immediately prior to the fall.



Photograph of skylight viewed from east to west



Metal conduit and firemain pipe struck by subject during descent



Lifeline entangled with the small diameter control line

During his descent, the subject struck a conduit and a fire main piping, which absorbed some of the energy and slowed the downward acceleration. He may also have contacted a metal stair handrail. The fall was arrested prior to the subject's torso striking the building floor when his lifeline became entangled with the skylight hatch coaming and a small diameter nylon rope being used as an OSHA control line to identify areas requiring fall protection on the roof. The skylight was not identified as a fall hazard and was not in an area where fall protection was deemed necessary. The subject's torso was approximately one foot above the floor with his lower extremities contacting the floor when his lifeline became taut.

The EB-WA was on the ground floor of Building 5 and heard the sound of the broken skylight and observed the final stage of the subject's fall. He immediately called for assistance. On-site medical assistance arrived at the scene within approximately 2 minutes. Off-site ambulance and EMT's arrived at approximately 10:58 a.m. The subject was transported via helicopter to a local hospital at 11:35 a.m. On July 10, 1997, the subject was released from the hospital. The NSC Superintendent advised the Board that the subject returned to work on July 14, 1997 at another facility.

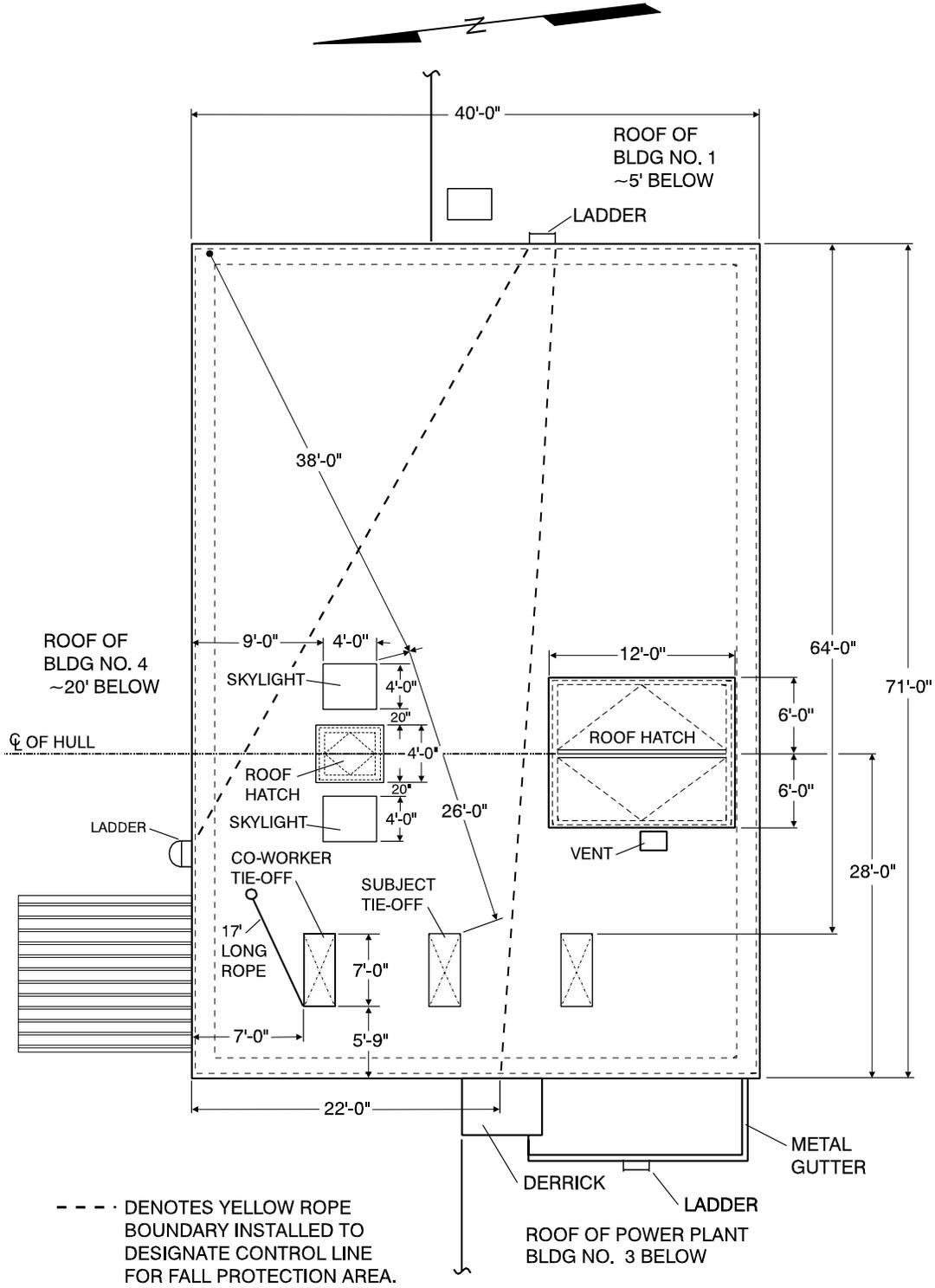
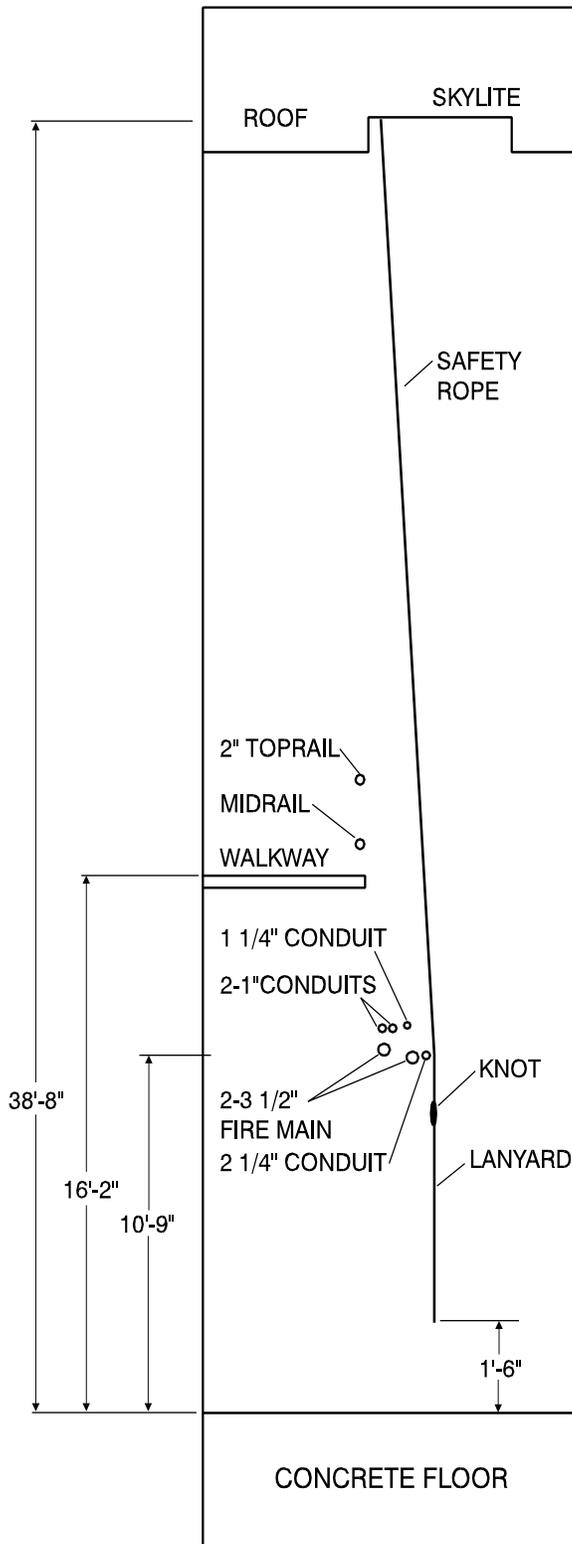


FIGURE 2: PLAN VIEW OF ROOF OF BUILDING 5



NOTES:

1. THE 2-1/4" CONDUIT WAS DEFLECTED DOWNWARD 10" TO THE CURRENT POSITION.
2. NO OTHER COMPONENTS WERE NOTED TO BE OFF LOCATION.

ELEVATION
CROSS-SECTION OF
BUILDING 5 AT POINT
OF APPARENT IMPACT
WITH PIPING (FACING EAST)

FIGURE 3: ELEVATION CROSS-SECTION OF BUILDING 5

2.1.2 CHRONOLOGY OF EVENTS

Appendix B summarizes the chronology of significant events.

2.2 PHYSICAL HAZARDS, CONTROLS AND RELATED FACTORS

2.2.1 PERSONNEL PERFORMANCE

Facts relating to personnel performance at the time of the accident are:

- Interviews revealed that the NSC Superintendent was also assigned the functions of OSHA competent person and the company's on-site safety representative.
- The NSC Superintendent failed to prepare a written fall protection plan as required by the Olshan/NSC Health and Safety Manual and contractually invoked EB safety specification.
- The subject and his co-worker had a limited comprehension of the English language. The general foreman is bilingual and was used, as necessary, as an interpreter whenever the subject or his co-worker could not understand the Superintendent. The Board was advised that a Spanish translation was determined to be necessary when requested by the subject and his co-workers or when a puzzled look was observed by NSC or EB personnel conversing in English with those individuals.
- Training was conducted by the NSC Superintendent on June 4, 1997 to meet the requirements of OSHA 29 CFR 1926.503. The training did not address skylights as a fall hazard. The training was in English and the handout materials were in English.
- The Building 5 roof work area had not been reviewed for potential hazards by EB or KAPL safety oversight personnel prior to work commencing. Work permits had been approved by EB Safety without visiting the work area.
- EB had advised Olshan in writing on July 3, 1997 that an evaluation of fall protection should be done before starting the Building 5 flashing removal. The EB Work Administrator allowed flashing removal to start before the fall protection evaluation was conducted.
- The morning safety briefing on July 7, 1997 conducted by the NSC Superintendent was on the topic of fall protection, specifically, requirements to cover holes and openings in the roof. The NSC Superintendent did not understand the hazards of skylights and did not address them during the briefing. The subject and his co-worker did not ask for clarification of the briefing from the interpreter.

- The subject left home in New Jersey at 0300 to travel to the Windsor Site the morning of the accident. The work day on the day of the accident started at 0700 permitting numerous water breaks, breaking for lunch at 1100, and finishing the day at 1530. Interviews did not indicate that the subject appeared tired or ill prior to the accident.
- The subject, his co-worker, and the general foreman had been ordered to stop work and take a break by the NSC Superintendent while he was absent from the roof and not return to work until the Superintendent returned.
- The subject was observed by the EB Work Administrator just prior to the accident working at the northeast corner of Building 5 roof utilizing his fall arrest system without the NSC Superintendent being present. The general foreman and foreman were also absent from the roof.
- While working in the northeast corner of the roof, the subject was not limited to a six-foot fall distance on the north edge of the roof. The Building 4 roof was approximately 20 feet below the north edge of the Building 5 roof. The EB Work Administrator failed to note that the subject was not protected from greater than a six foot fall on the north edge and also failed to note the unguarded and uncovered skylights were a fall hazard in accordance with OSHA 29 CFR 1926.501(b)(4). The EB Work Administrator did not have an in-depth knowledge of the OSHA fall protection standard.
- A co-worker working on the northwest edge of the roof was also not limited to a six-foot fall distance by his fall arrest system.
- At the time of the fall, the NSC general foreman was on the Building 5 roof and failed to observe that neither worker was protected from a fall in excess of six feet at the edges of the roof.
- The subject's co-worker and general foreman observed the subject moving backwards and placing his foot on the skylight. The skylight broke causing the subject to lose his balance and fall backward through the skylight.

2.2.2 MANAGEMENT SYSTEMS

2.2.2.1 POLICIES AND PROCEDURES

- KAPL contracted with EB to perform prototype dismantlement and site inactivation at the Windsor Site. EB contracted the demolition work to Olshan. Olshan subcontracted with NSC for asbestos removal prior to demolition of Buildings 1, 1A, and 5.
- In accordance with DOE Order 440.1, KAPL is responsible for establishing and maintaining an effective worker protection program. To fulfill this responsibility, KAPL provides oversight of all work performed at the Windsor Site.
- KAPL performed and documented the results of environmental, health, and safety surveillances in accordance with Chapter 15 of the KAPL Safety Manual. This instruction, however, did not require trend analysis of observed deficiencies.
- Under its subcontract with KAPL, EB is responsible for oversight of work performed at the Windsor Site by EB and EB subcontractors. While EB conducted periodic surveillances of work in progress, there is no written procedure that describes this function.
- EB contractually invoked KAPL Safety Specification S-12 on Olshan and contractually required it to be passed down to lower tier subcontractors. Specification S-12 requires compliance with the OSHA construction safety standards. Section II, paragraph E.4 of S-12, specifically required NSC to submit a fall protection plan to EB for approval.
- NSC informed EB by letter that they had adopted the Olshan Health and Safety Manual as their on-site health and safety manual. Procedure 3-6 of the Olshan/NSC Health and Safety Manual covers fall protection. Procedure 3-6 requires preparation of an Appendix A, Fall Protection Plan, and that it be kept on file. Appendix A was not prepared for the Building 5 roof work.

2.2.2.2 HAZARDS ANALYSIS

Facts relating to hazards analysis are as follows:

- Interviews revealed that a job hazard/safety analysis was not performed for the roofing work.
- A fall protection plan was not prepared as required by the Olshan/NSC health and safety manual and submitted to EB for approval as required by contract.

- EB allowed work to commence without a fall protection plan.
- Interviews with KAPL, EB, Olshan, and NSC personnel identified that personnel were unaware of the fall hazard presented by skylights.

2.2.2.3 PHYSICAL BARRIERS

On the day of the accident:

- The anchor points chosen for the horizontal lifelines would limit a worker's fall distance to six feet only when the worker was at 90° to the rectangular shaped anchor point. In addition, the skylights were not in the area designated as requiring fall protection. See Figure 2.
- The control line established in accordance with OSHA 29 CFR 1926.502(g) to identify the area requiring fall protection did not encompass the northwest corner of the roof where the co-worker was assigned to work. In addition, the control line sagged 21" below the OSHA-required 39" height and was not flagged at six-foot intervals as required by the OSHA fall protection standard.
- Interviews with NSC personnel identified that the NSC Superintendent/competent person had gone from the Building 5 roof to the adjacent Building 1 roof earlier in the morning and had been involved with picking up removed flashing from the Building 5 roof, distracting him from observing the work on Building 5. At the time of the accident, the NSC Superintendent/competent person was not at the work area.
- The two NSC laborers on the Building 5 roof wore full-body harnesses equipped with a rip-stitch lanyard. The subject's lanyard was hooked to a knot in a 5/8" diameter lifeline that was approximately 64 feet long from the anchor point. The length of lifeline allowed the subject to work on the northeast side of the roof, but would not have prevented a fall of approximately 20 feet to the Building 4 roof on the north side. The lifeline is rated at 11,400 lbs. tensile strength, down rated to 5,700 lbs. due to using knots for the connection to the harness lanyard. The lifeline met the OSHA 29 CFR 1926.502(d)(9) strength requirement of 5,000 lbs.
- The co-worker utilized a similar fall arrest system as the subject. He was hooked to a 17-foot lifeline of the same material as the subject's. The co-worker's anchor point was seven feet away from the roof edge; therefore, not limiting him to a fall distance of six feet.

- A post accident analysis of a piece of the broken plastic skylight dome identified the material as poly (methyl methacrylate). This material is known by the trade names Plexiglas and Lucite and is widely used for window glazing and similar applications. Poly is subject to damage from UV radiation, such as is present in natural sunlight. This damage weakens the material and makes it brittle. Physically, this damage, if present, is visible as a network of tiny cracks on the surface of the material, a phenomenon known as crazing. Extensive crazing is evident on the poly sample from the Building 5 skylight. The extent of crazing present implies that the sample is brittle and substantially weaker than the new product.

2.2.2.4 SUPERVISION, MANAGEMENT AND OVERSIGHT

- Olshan and NSC corporate safety personnel periodically assess the safety conditions at their companies' work sites; however, no assessments were conducted during the time roofing work was performed at the Windsor Site.
- Procedure 1-2 of the Olshan Health and Safety Manual requires the Olshan Safety Coordinator to perform weekly inspections of work areas and to document environmental, safety and health deficiencies. Section I, paragraph I of Safety Specification S-12, also requires the on-site safety representative to conduct weekly inspections of the work area. Olshan presence on site consisted of one individual, the Project Manager. The Olshan Corporate Safety Director stated that the Project Manager was also the Safety Coordinator, and the on-site Safety Representative required by Section I, paragraph BB of Safety Specification S-12. The Project Manager stated to the Board that he was not the Safety Coordinator, nor the safety representative, and was not performing work area inspections.
- The NSC Superintendent was also the NSC on-site Safety Coordinator/safety representative and the OSHA competent person for asbestos abatement and fall protection. He performed a daily checklist inspection of the work area, copies of which were forwarded to Olshan. Review of the inspection checklists for the period May 23, 1997 to the time of the accident revealed that no safety problems were identified.
- Review of available documentation and interviews identified that there had been recurring problems with fall protection involving EB workers during the past several months and with NSC following start of roof work. In the five months prior to the accident, KAPL issued over 200 environment, safety, and health deficiency notices. Twenty deficiencies related

to fall protection were identified and brought to EB management attention on a case-by-case basis. Although action had been taken with individual personnel observed violating fall protection requirements, neither KAPL, EB, Olshan nor NSC recognized and acted on the chronic nature of the repetitive deficiencies.

- Documentation of deficiencies by EB was sporadic and a tracking system for following individual deficiencies to closure and for trending analyses was not utilized.
- On September 26, 1996, a Schenectady Naval Reactors Office review of safety and health programs at the Windsor Site identified fall protection deficiencies.
- The Windsor Field Office (WFO) identified six fall protection deficiencies to KAPL and EB management from January-July 1997. WFO identified fall protection as a continual problem in two May 1997 biweekly safety meetings with the KAPL and EB safety managers.
- A Naval Reactors headquarters' review of Windsor Site activities in May 1997 identified several fall protection issues. In addition, Naval Reactors expressed a concern whether the manning levels of the EB Safety Department might not be able to support oversight of subcontracted building demolition work concurrent with EB prototype dismantlement work. Naval Reactors further pointed out that EB safety personnel were devoting too much effort to directly supporting production efforts vice providing oversight.
- Interviews with EB safety personnel and the EB Work Administrator identified a lack of discipline to document and analyze deficiencies with subcontractor work.
- Over the past six months, senior KAPL and EB management have devoted much effort and attention to improving performance in the environmental area, particularly with regard to waste management. As a result, senior management attention was diverted from safety performance.
- WFO did not ensure that the issue of continual fall protection problems was brought to the attention of KAPL and EB senior management for resolution.

2.3 BARRIER ANALYSIS SUMMARY

Barrier analysis is a method of determining safety system elements that failed. A barrier analysis was performed that was applicable to this accident and included administrative controls, physical barriers, and management barriers. The successful performance by any one of these types of barriers would most likely have prevented the accident. Appendix C provides the details of the analysis.

Barriers that failed include the lack of a fall protection plan, the lack of knowledge by workers, supervisory and oversight personnel, and lack of proper implementation of OSHA fall protection requirements.

In accordance with the Olshan Safety and Health Manual, NSC management is required to conduct an OSHA compliant survey of the types of fall hazards which are expected to be encountered and develop a fall protection plan relative to providing the kind and number of safeguards that are needed to protect against these fall hazards. NSC management did not provide a fall protection plan. In addition, NSC did not recognize that the skylight dome material had weakened due to UV damage caused by prolonged exposure to sunlight.

Prior to work on the Building 5 roof, the NSC Superintendent who is also the "competent person" for fall protection did not recognize that skylights are a fall hazard in accordance with OSHA 29 CFR 1926.501(b)(4). In addition, during daily morning pre-job briefings, the NSC Superintendent did not address skylights as a fall hazard. The NSC Superintendent did not receive adequate OSHA fall protection training and lacked sufficient knowledge of OSHA fall protection requirements to ensure an adequate fall protection system would be in place during Building 5 roof work. NSC management allowed employees to work on the Building 5 roof without the training required to perform the work safely.

The NSC Superintendent established an area on the Building 5 roof requiring fall protection and replaced two lines that were previously installed to identify a path of travel to ladder ways on the Building 5 roof. However, the new control lines did not demarcate the six-foot distance from the Building 5 roof edge, nor were the control lines installed around the Building 5 skylights. A properly prepared fall protection plan would have identified control lines six feet from the roof edge and the skylights. The lifeline tie-off points established on the Building 5 roof limited the potential fall distance to six feet in a small area of the roof which necessitated constant attention to adjusting the length of the lifeline as roof work progressed around the roof edges. A properly prepared fall protection plan would have identified a more reliable lifeline tie-off system.

The NSC Superintendent also had collateral duties which required work assignments away from the Building 5 roof. As a result, the NSC Superintendent was not able to provide constant surveillance or monitoring of workers when fall protection methods changed as work progressed on the Building 5 roof.

As a result of past problems, top KAPL and EB management attention had been focused on waste and environmental issues. Numerous fall protection deficiencies had been identified; however, these deficiencies were not always documented, a trend analysis was not utilized, and adequate corrective action was not taken to prevent recurrence. As a result, fall protection problems continued to occur at the Windsor Site.

Neither the Olshan Project Manager nor the KAPL/EB safety representative inspected the Building 5 roof prior to commencing work on the morning of the accident.

2.4 CHANGE ANALYSIS SUMMARY

Change is one of the most important causes of accidents. Change analysis examines planned or unplanned changes that caused undesired outcomes. A change analysis was performed to determine points where changes are needed to correct deficiencies in the safety management system and to pinpoint changes that may have directly affected the accident. Appendix D provides details of the analysis.

Changes that directly contributed to the accident were the absence of a fall protection plan, including associated reviews and approval for the elevated roof work evolutions, and failure to recognize the two unprotected skylights as fall hazards in the work area. The failure to ensure completion and submittal of a fall protection plan can be attributed to ineffective project overview by EB. Failure to recognize the skylight as a fall hazard is directly related to inadequate knowledge and hazard recognition skills by all contractor and subcontractor individuals responsible for task performance and compliance monitoring.

Changes related to the safety monitor's inability to properly perform task expectations contributed to ineffective hazard recognition and increased risk potential. This individual was not fully knowledgeable of a safety monitor's role and responsibilities.

Workforce language barrier was a change which was not accommodated to adequately ensure work briefs and safety training evolutions were fully understood.

The change analysis results are consistent with the barrier and causal factor analyses. The Change Analysis Worksheet summarizes the results of all analyses. Refer to the Barrier Analysis Write-up for more information related to change factors.

2.5 PROBABLE CAUSAL FACTORS

Appendix E depicts the logical sequence of the events and causal factors for the accident. It indicates, in a time-sequenced flow, factors that allowed the accident to occur.

The **direct cause** of the accident was the fall through an unprotected roof skylight. However, there were also contributing causes (causes that, if corrected, would not, by themselves, have prevented the accident but are important enough to be recognized as needing corrective action) and root causes (the fundamental causes that, if corrected, would prevent recurrence of this and similar occurrences).

Contributing causes for the accident were:

- Failure by all involved to recognize Building 5 skylights as openings requiring fall protection.
- Limited knowledge of fall protection requirements by NSC workers and supervisors, and Olshan/EB oversight personnel.
- Lack of a written fall protection plan.
- Lack of a management process to ensure performance of pre-job hazard analyses.
- Lack of KAPL and EB management processes to perform trend analysis of observed deficiencies.
- KAPL management not holding EB fully accountable for safety performance.
- Olshan Project Manager failed to accept safety coordinator responsibility.
- Work conducted without NSC Superintendent being present, who was acting as safety monitor.
- NSC Superintendent assigned both production and safety monitor duties.
- EB Safety Manager had limited knowledge of health and safety requirements.

- Senior KAPL and EB management focused on waste management and environmental regulatory compliance.
- The Plexiglas dome of the skylight was substantially weaker than new product as a result of UV damage due to 38 years of exposure to sunlight.

Root causes of the accident were:

- EB, Olshan, and NSC management failed to ensure that fall protection requirements were properly understood and implemented in accordance with both contractual and applicable regulatory requirements.
- EB and KAPL site management failed to identify and resolve reasons for recurring fall protection deficiencies prior to the accident. WFO failed to ensure that chronic fall protection problems were brought to the attention of and resolved by KAPL and EB senior management.

Table 2-1 CAUSAL FACTOR ANALYSIS

ROOT CAUSES	DISCUSSION
Management Responsibilities	EB, Olshan, and NSC management failed to adequately implement contractual requirements for contractor safety programs. EB and KAPL site management failed to identify and resolve reasons for recurring fall protection deficiencies. WFO failed to ensure that chronic fall protection problems were brought to the attention of and resolved by KAPL and EB senior management.
Safety Requirements Implementation	Olshan and NSC failed to implement OSHA 29 CFR 1926 Subpart M requirements for a fall protection system and ensure personnel were familiar with the hazards of the work site.

CONTRIBUTING CAUSES	DISCUSSION
Hazard Analysis	A pre-job hazard analysis was not performed which resulted in personnel not recognizing the skylights as a fall hazard.
Procedures	A fall protection plan was not prepared in accordance with Olshan procedures adopted by NSC. EB did not require a fall protection plan be submitted by NSC for approval as required by the Olshan contract with NSC and Safety Specification S-12.
Oversight	Work proceeded on the roof without the NSC Superintendent/safety monitor being present. The NSC Superintendent/safety monitor was assigned duties in addition to those of the safety monitor. KAPL management did not hold EB fully accountable for safety performance. Senior KAPL and EB management focus was on waste management and environmental regulatory compliance issues.

3.0 CONCLUSIONS AND JUDGMENTS OF NEED

This section of the report identifies the conclusions and judgments of need determined by the Board using the accident analysis methods described in Section 2.0. Conclusions of the Board considered significant facts and the analytical results.

Judgments of need are managerial controls and safety measures believed necessary to mitigate the probability or severity of a recurrence. They flow from the conclusions and causal factors. Table 3-1 identifies the conclusions and the corresponding Judgment of need identified by the Board.

Table 3-1 Conclusions and Judgments of Need

CONCLUSION	JUDGMENTS OF NEED
1. Comprehensive safety requirements exist, are contractually invoked, and are appropriate for the nature of the demolition work.	None
2. NSC failed to comply with its Health and Safety Manual invoked by paragraph I.F of Safety Specification S-12. A fall protection plan for the roof work was not prepared. A properly prepared fall protection plan would have required the skylights to be covered or guarded.	Fall protection plans should be prepared by NSC and approved by both Olshan and/or EB prior to the start of elevated work. These plans should be specific to the work site and be checked against all applicable safety requirements.
3. The NSC Superintendent assumed safety monitoring duties for the roof fall protection in addition to his other duties, limiting his ability to continuously monitor the work in progress.	Whenever the use of a safety monitor is selected to meet OSHA fall protection requirements, the safety monitor should not have other assigned duties.
4. NSC, Olshan, EB, and KAPL failed to ensure workers, supervisory personnel and oversight personnel were adequately trained to recognize fall hazards when working on low pitched roofs.	NSC workers should be retrained on the requirements for fall protection. NSC, Olshan, EB, and KAPL oversight and supervisory personnel should also be re-trained.

CONCLUSION	JUDGMENTS OF NEED
5. Olshan failed to provide safety oversight of their asbestos subcontractor, NSC as required by the Olshan Health and Safety Manual and Safety Specification S-12. The Olshan Project Manager did not consider safety oversight as his responsibility.	Olshan needs to staff a trained, competent, safety professional on-site who will be responsible for the oversight of their subcontractors.
6. EB and KAPL safety oversight personnel failed to identify the lack of adequate fall protection on the Building 5 roof. In addition, EB and KAPL failed to recognize that a fall protection plan had not been submitted for approval as required by Safety Specification S-12.	EB and KAPL safety personnel should be re-trained in the fall protection requirements. EB must ensure that all contractual requirements are met by their subcontractors (including submitting fall protection plans).
7. EB and KAPL management failed to recognize and act on the chronic nature of repetitive deficiencies preceding this event. This was due in part to the lack of safety knowledge and experience by the EB safety manager. In addition, top management attention (EB and KAPL site managers) was focused on environmental regulatory issues.	EB should be responsible for conducting trend analysis of various safety deficiencies and reviewing their results periodically with KAPL management. Actions to correct repetitive problems should be identified and followed by EB and KAPL.
8. WFO did not ensure that the issue of continual fall protection problems was brought to the attention of KAPL and EB senior management for resolution.	WFO should ensure that chronic safety problems are brought to the attention of and resolved by KAPL and EB senior management in a timely manner.

4.0 BOARD SIGNATURES

A. R. Seepo, Board Chairperson
U. S. Department of Energy
Schenectady Naval Reactors

Date: _____

J. P. Hughes Robillard, Board Member
DOE Trained Accident Investigator
U. S. Department of Energy
Schenectady Naval Reactors

Date: _____

J. M. Cochran, Board Member
DOE Trained Accident Investigator
U. S. Department of Energy
Schenectady Naval Reactors

Date: _____

S. Burinski, Board Member
DOE Trained Accident Investigator
U. S. Department of Energy
Pittsburgh Naval Reactors

Date: _____

M. Roper, Board Member
Safety Specialist
U. S. Department of Energy
Pittsburgh Naval Reactors

Date: _____

5.0 BOARD MEMBERS, ADVISORS AND STAFF

A. R. Seepo, Board Chairperson
Schenectady Naval Reactors

J. P. Hughes Robillard, DOE Trained Accident Investigator
Schenectady Naval Reactors

J. M. Cochran, DOE Trained Accident Investigator
Schenectady Naval Reactors

S. Burinski, DOE Trained Accident Investigator
Pittsburgh Naval Reactors

M. Roper, Safety Specialist
Pittsburgh Naval Reactors

P. J. Bennice, Consultant
Lockheed Martin - KAPL Inc.

G. J. Vitullo, Consultant
Lockheed Martin - KAPL Inc.

J. A. Nuzback, Consultant
Lockheed Martin - KAPL Inc.

R. Cuervo Jr., Translator
Lockheed Martin Inc.

APPENDIX A

REC&SD:ARS97-20
JUL 08, 1997

MEMORANDUM FOR: Distribution

APPOINTMENT OF INVESTIGATION BOARD

I hereby establish a Type B Accident Investigation Board to investigate the personal injury accident which occurred at the Windsor Site on July 7, 1997 involving a subcontractor employee who fell through a building rooftop skylight. I have determined it meets the requirements established for a Type B accident investigation in accordance with DOE Order 225.1, Accident Investigations, as implemented by Naval Reactors Bulletin 225.1-95, Revision 0, dated January 14, 1997.

I appoint A. R. Seepo as the accident board chairperson. The board members will be J. M. Cochran (SNR), J. P. H. Robillard (SNR), M. C. Roper (PNR), and S. R. Burinski (PNR). The board will be assisted by advisors and consultants and other support personnel as determined by the chairperson.

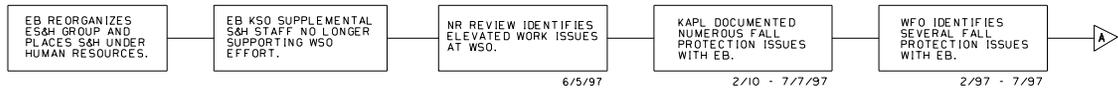
The scope of the board's investigation will include, but is not limited to: identifying all relevant facts; analyzing the facts to determine the direct, contributing, and root causes of the accident; developing conclusions; and determining the actions that, when implemented, should prevent the recurrence of the accident. The investigation will be conducted in accordance with DOE Order 225.1 and will specifically address the role of DOE and contractor organizations and management systems as they may have contributed to the accident.

The board will provide my office with periodic reports on the status of the investigation, but will not include any conclusions until an analysis of all the causal factors has been completed. Draft copies of the factual portion of the investigation report should be provided to the Windsor Field Office, KAPL, and EB-Windsor Site officials for a factual accuracy review prior to report finalization.

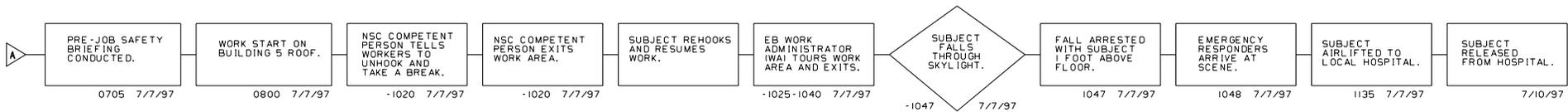
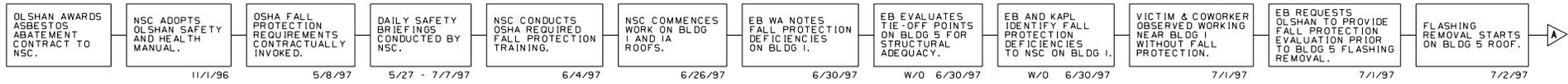
The report should be provided to me for acceptance within 30 days from the date of this memorandum. Discussions of the investigation and copies of the draft report will be controlled until I authorize release of the final report.

P. E. Salm
Manager

APPENDIX B
CHRONOLOGY OF EVENTS
(IN PRINTED COPY ONLY)



KEY	
SYMBOLS	ACRONYMS
	= EVENT
	= ACCIDENT
	= TRANSFER
	EB - ELECTRIC BOAT DIV.(GEN. DYNAMICS)
	ES&H - ENVIRONMENTAL, SAFETY AND HEALTH
	HR - HUMAN RESOURCES
	KAPL - KNOLLS ATOMIC POWER LAB.
	KSO - KESSELING SITE OPERATION
	NR - NAVAL REACTORS
	NSC - NATIONAL SURFACE CLEANING
	OSHA - OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
	SBH - SAFETY AND HEALTH
	WA - WORK ADMINISTRATOR
	WFO - WINDSOR FIELD OFFICE



APPENDIX B - CHRONOLOGY OF EVENTS

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APPENDIX C

BARRIER ANALYSIS

HAZARD	DIRECT BARRIER FAILURE	FACTORS CONTRIBUTING TO FAILURE	ROOT CAUSE	POTEN. LOSS EVENT	EVALUATION
Fall through skylight	Failure to cover skylight	Skylight not recognized as a fall hazard	Lack of knowledge of OSHA fall protection standard. Lack of fall protection plan.	Fall	NSC personnel and EB oversight personnel had a limited knowledge of fall protection requirements. NSC did not comply with contractual and site requirements to have a fall protection plan.
	Failure to erect guard around skylight	Skylight not recognized as a fall hazard. Inadequate number of guardrails available.	Lack of knowledge of OSHA fall protection standard. Lack of fall protection plan.		NSC personnel and EB oversight personnel had a limited knowledge of fall protection requirements. NSC did not comply with company and contractual requirements to have a fall protection plan.

HAZARD	DIRECT BARRIER FAILURE	FACTORS CONTRIBUTING TO FAILURE	ROOT CAUSE	POTEN. LOSS EVENT	EVALUATION
	Failure to include skylights in the area designated as requiring fall protection	Skylight not recognized as a fall hazard.	Lack of knowledge of OSHA fall protection std. Lack of fall protection plan.		NSC personnel and EB oversight personnel had a limited knowledge of fall protection requirements. NSC did not comply with company and contractual requirements to have a fall protection plan.
	Skylight dome material weakened due to age	Natural sunlight causes damage from UV exposure.	Physical characteristic of skylight dome material.		Aging of material significantly weakened its strength aggravating fall hazard potential.

HAZARD	DIRECT BARRIER FAILURE	FACTORS CONTRIBUTING TO FAILURE	ROOT CAUSE	POTEN. LOSS EVENT	EVALUATION
	Failure of NSC safety monitor to limit personnel to six-foot fall distance	Safety monitor had additional duties.	Safety monitor was also the NSC site Superintendent with work in progress on an adjacent roof. Site Superintendent was required to exit roof to correct a posting problem and receive a vendor delivery.		Safety monitor responsibilities, when used as part of a fall protection system can not be assigned to anyone with other duties that can distract his attention from the elevated work in progress.

HAZARD	DIRECT BARRIER FAILURE	FACTORS CONTRIBUTING TO FAILURE	ROOT CAUSE	POTEN. LOSS EVENT	EVALUATION
	Lifeline was too long to minimize falls to six feet	Tie-off point selected for the job only limited the potential fall distance to six feet in a small area of the roof, necessitating constant attention to work progress and frequent changes to the length of the line	Lack of a fall protection plan which should have identified need for a different system.		Neither Olshan, NSC nor EB personnel with oversight responsibility took action to assure fall protection plan was prepared and approved for the job.
	Control line was not established at six feet from edges of roof	NSC replaced a previously installed line used to identify a travel path with a control line that was not installed at six feet from all roof edges or skylights	Lack of fall protection plan. Lack of knowledge of OSHA fall protection std.		The NSC competent person/safety monitor, and EB and KAPL personnel with oversight responsibility failed to identify inadequate control line.

HAZARD	DIRECT BARRIER FAILURE	FACTORS CONTRIBUTING TO FAILURE	ROOT CAUSE	POTEN. LOSS EVENT	EVALUATION
	Training of workers did not address skylights as a hazard	Lack of knowledge of skylights as a fall hazard	Lack of understanding of OSHA fall protection standard. Inadequate training of NSC site Superintendent who conducts job-site training.		NSC Daily safety meetings addressed fall protection requirements for 9 consecutive days but did not address skylights.
	Job site not inspected by EB or KAPL safety oversight personnel prior to start of work	There were other subcontractors working on site which had the safety oversight personnel's attention	Lack of prioritizing jobs to review based on hazard/risk		A review of the job site by safety oversight personnel should have identified inadequate fall protection system.

HAZARD	DIRECT BARRIER FAILURE	FACTORS CONTRIBUTING TO FAILURE	ROOT CAUSE	POTEN. LOSS EVENT	EVALUATION
	Lack of effective corrective actions by EB and KAPL taken in response to continuing site-wide fall protection issues	Lack of adequate deficiency documentation and trend analysis.	Most of EB and KAPL ES&H oversight attention has been placed on waste and environmental issues		Adequate documentation and trending of safety deficiencies would have identified a continuing problem with fall protection issues throughout the site.
	NSC failed to submit a fall protection plan for approval	EB failed to require asbestos abatement contractor to submit the required fall protection plan	EB personnel did not understand requirement for submittal of fall protection plan for approval		NSC and EB allowed work to commence on roof without a fall protection plan.
	NSC failed to comply with Olshan/NSC Safety and Health Manual	NSC did not submit a fall protection plan in accordance with the Safety and Health Manual.	NSC failed to follow requirements of Safety and Health Manual		Protection against fall hazards were not identified and approved.

APPENDIX D

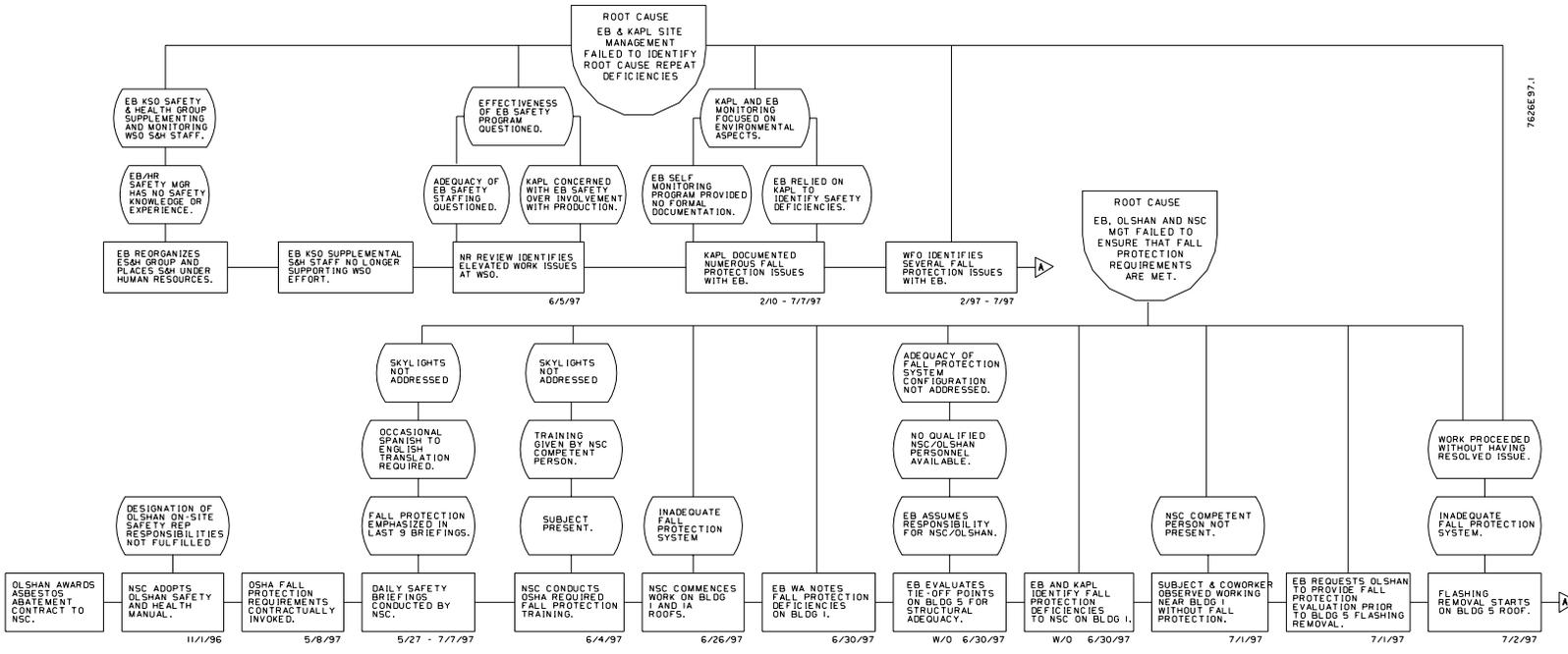
CHANGE ANALYSIS WORKSHEET

<i>CHANGE or DIFFERENCE</i>		<i>ANALYSIS</i>	
Planned/Normal	Present	Difference	Analysis
All fall hazards, any area where a fall potential of six feet or greater is present (including skylights), identified and properly guarded or posted to limit access to within six feet of the unprotected opening.	Skylight was not guarded or posted to preclude the fall danger.	Skylight was not recognized as a potential fall hazard.	Failure to recognize the skylight as a fall hazard within the work space was the major contributing cause for the fall.
A written and approved fall protection plan is prepared, reviewed by an overview organization and employees are trained to the plan.	A written fall protection plan was not prepared for the elevated roof work evolutions.	EB failed to require a written fall protection plan for the elevated roof work evolutions, consequently no review was performed to evaluate for regulatory compliance.	Preparation and submittal of a fall protection plan by the contractor to EB may have provided an opportunity to identify all fall hazards and adequate protective measures.

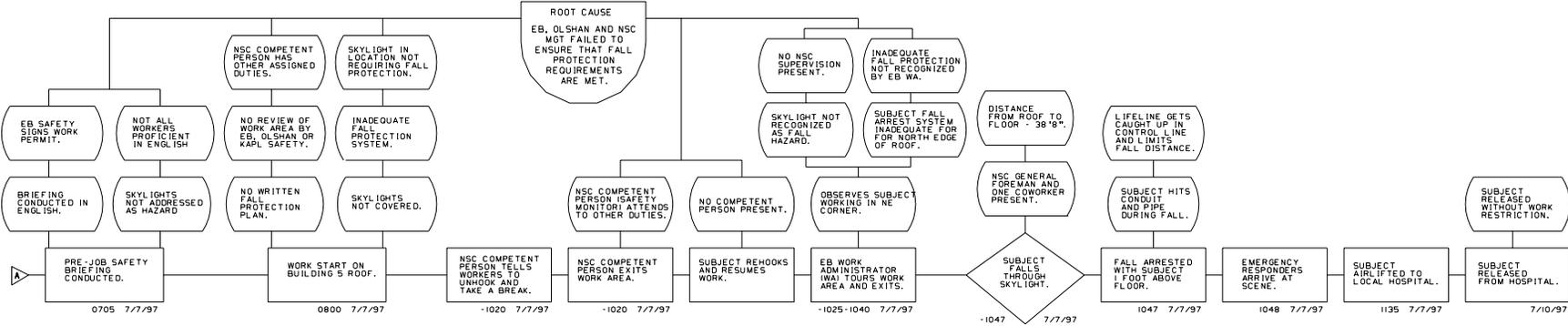
CHANGE or DIFFERENCE		ANALYSIS	
Planned/Normal	Present	Difference	Analysis
<p>A control line is erected to indicate "controlled access zones" where personal fall arrest equipment is necessary for work within six feet of fall hazards.</p>	<p>The control line was placed in a manner which allowed encroachment to within six feet of the roof edge. Control line was lower than 39 inches, did not have flags attached and did not provide adequate tensile strength (200 lb min.).</p>	<p>Control line was not properly positioned the required distance from the roof edge, was lower than required height and not properly flagged.</p>	<p>The control line height may have contributed to a tripping and/or entanglement hazard in the work area. Unknown as to if this propagated the trip/fall into the skylight.</p>
<p>Trip and fall hazards are minimized on the roof surface through good housekeeping and tool/equipment storage practices.</p>	<p>The removed roof edge flashing and tools were laying on the roof surface in the vicinity of the skylight. A control line in the roof was positioned too low (< 39 in.).</p>	<p>The roof work surface was not free from tripping hazards.</p>	<p>The control line height, flashing and/or tools on the roof may have contributed to a tripping and/or entanglement hazard in the work area. Unknown as to if this propagated the trip/fall into the skylight.</p>

CHANGE or DIFFERENCE		ANALYSIS	
Planned/Normal	Present	Difference	Analysis
Verbal and written instructions provided to employees during training and pre-work briefings factor in and accommodate for workforce language barriers.	The job briefings and all written safety instructions were presented in English. Two workers assigned to the Building 5 roof work are not proficient in the English language (Spanish speaking). A foreman working with the two non-English speaking employees performs translation as necessary.	Work instruction and written procedures were not bilingual (English and Spanish) to ensure full understanding by workers not proficient in the English language.	Language barriers may have contributed an inadequate understanding of job safety expectations (e.g. fall arrest system adjustments for work area changes).

APPENDIX E
EVENT AND CAUSAL CHART
(IN PRINTED COPY ONLY)



KEY	
SYMBOLS	
[Rectangle]	= EVENT
[Oval]	= CONDITION
[Diamond]	= ACCIDENT
[Triangle]	= TRANSFER
ACRONYMS	
EB	- ELECTRIC BOAT DIVISION DYNAMICS
ES&H	- ENVIRONMENTAL, SAFETY AND HEALTH
HR	- HUMAN RESOURCES
KAPL	- KNOLLS ATOMIC POWER LAB.
KSO	- KESSELRING SITE OPERATION
NR	- NAVAL REACTORS
NSC	- NATIONAL SURFACE CLEANING
OSHA	- OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION
SBH	- SAFETY AND HEALTH
WA	- WORK ADMINISTRATOR
WFO	- WINDSOR FIELD OFFICE



APPENDIX E - EVENT AND CAUSAL CHART

APPENDIX F

ACRONYMS

DOE	U. S. Department of Energy
EB	Electric Boat
ES&H	Environment, Safety and Health
KAPL	Knolls Atomic Power Laboratory
NR	Naval Reactors
NSC	National Surface Cleaning Corporation
OLSHAN	Olshan Demolishing Management, Inc.
OSHA	Occupational Safety and Health Administration
SNR	Schenectady Naval Reactors
WFO	Windsor Field Office